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TASK 1

Title: Brain Tumor Detection using YOLOv11 and Segment Anything Model (SAM2)

Abstract:

This document presents the implementation process, findings, and observations of my project focused on detecting brain tumors using deep learning models, specifically YOLOv11 for object detection and Meta AI's SAM2 (Segment Anything Model) for segmentation. The goal of the project was to automate and enhance the accuracy of brain tumor identification in MRI scans, facilitating early and precise diagnosis.

Objective:

To develop an automated system for brain tumor detection and segmentation using advanced object detection and segmentation models. This system aims to:

- Detect the presence of a tumor using YOLOv11.
- Accurately segment the tumor region using SAM2.

Dataset:

The dataset consists of annotated brain MRI images containing both tumorous and non-tumorous cases. Images were preprocessed and divided into appropriate training and validation sets. Annotations were used for training YOLOv11, while masks and bounding boxes guided SAM2 for segmentation.

Implementation Steps:

1. **Environment Setup:**
    - Jupyter Notebook was used as the development environment.
    - Required dependencies were installed, including PyTorch, Ultralytics YOLOv11, and SAM2 libraries.
2. **Data Preparation:**
    - Brain MRI images were loaded and labeled.
    - Annotations were formatted to be compatible with YOLOv11.
    - Data augmentation and splitting into training/validation sets were performed.
3. **Model Training - YOLOv11:**
    - YOLOv11 was trained to detect brain tumors.
    - Training parameters: epochs, learning rate, batch size, etc., were fine-tuned.
    - The trained model was validated on unseen images.

4. **Tumor Segmentation - SAM2:**

    - The YOLO-detected bounding boxes were used as prompts for SAM2.
    - SAM2 segmented the tumor regions from within the detected boxes.

5. **Evaluation & Visualization:**

    - Detection and segmentation outputs were saved under the runs/ directory.
    - Visual results included bounding boxes and segmented masks on MRI images.

Findings:

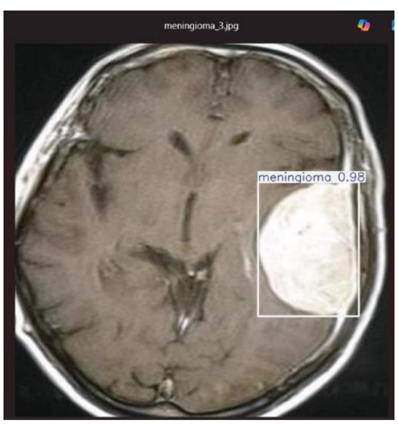
- YOLOv11 showed high precision in locating tumor regions across diverse MRI scans.
- SAM2 was effective in extracting fine-grained tumor boundaries, even in low-contrast areas.
- Combining both models enhanced reliability over using either individually.

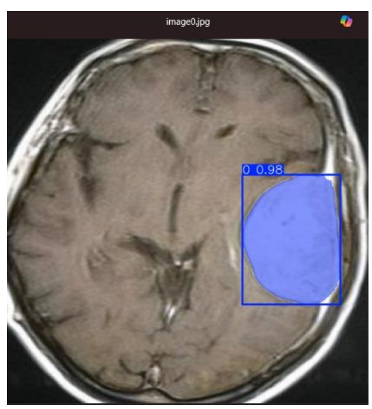
Observations:

- Preprocessing and annotation consistency significantly affected YOLOv11 performance.
- SAM2 worked well with accurate bounding boxes but was sensitive to incorrect detections.
- Running both models sequentially provided a streamlined workflow for clinical use cases.

Screenshots:

The following figures are taken from the runs/ folder generated during model testing and inference:





Conclusion:

This project successfully implemented a pipeline combining object detection and segmentation for brain tumor detection. The integrated use of YOLOv11 and SAM2 demonstrated effective and accurate identification of tumor regions, showcasing strong potential for real-world medical imaging applications.Future enhancements could involve fine-tuning the models further with domain-specific data, integrating 3D MRI volumes, and deploying the system into a clinical decision support platform.